and examples as defined within the scope of all claims based on this disclosure, as well as all legal equivalents of such claims.

**[0014]** For the purposes of this specification, a "computing system," a "processor-based system" or "processing system" includes a system that uses one or more processors, microcontrollers and/or digital signal processors and that has the capability of running a "program." As used herein, the term "program" refers to a set of executable machine code instructions, and as used herein, includes user-level applications as well as system-directed applications or daemons, including operating system and driver applications. "Processing systems" include communication and electronic devices, such as mobile phones (cellular or digital), music and multi-media players, and Personal Digital Assistants (PDAs); as well as computers, or "computing devices" of all forms and configurations (desktops, laptops, servers, palmtops, workstations, etc.).

**[0015]** Referring now to FIG. **1**, therein is depicted a representation of computing system **100** including an input device in the form of a virtual keyboard **108** with a haptic feedback system configured to suppress propagating vibrations in one common operating configuration. Many configurations of virtual keyboards have been proposed, and will be recognized by those skilled in the art. In this example, virtual keyboard **108** will be discussed in the form of a single unitary surface, such as a glass or metallic plate, having a plurality of contact locations defined thereon, with each such contact location outlined in a conventional keyboard pattern. For purposes of the present description the contact locations of virtual keyboard **108** (the virtual "keys") have been outlined and shaded, but any desired surface appearance may be used for virtual keyboard **108**. As will be apparent from the following discussion, the methods and apparatus described are applicable both to much simpler and to more complicated input devices. For example, the input device can be a mouse, a touch screen, a keypad of a mobile communications device, or another type of input interface, etc. Virtual keyboard **108** includes a plurality of contact locations **110** (in this example, each virtual "key" site). Virtual keyboard **108** is configured to detect user inputs, and to communicate those user inputs to computing device **102** through a wired or wireless connection. Contact locations can e any location where a user may be anticipated to contact the input device to interact with it. The detection of a "key" actuation may be performed by any of several mechanisms known in the art, and may be in response either to physical contact with the input surface, or alternatively to proximity of a user to a contact location. Those skilled in the art will recognize that the user input detection system may be of any of the known such systems, including capacitance or inductive sensors, laser sensing, etc. In many embodiments of systems described herein, the haptic feedback system will be entirely separate from the user input detection system. However, the actuators as described herein could also be used as a user input detection mechanism. For example, piezoelectric actuators may be used as sensors to convert physically-induced vibration or displacement into an electrical signal. Thus, such actuators may also be used to detect a user-initiated input.

**[0016]** For purposes of this example, virtual keyboard **108** will be understood to include a haptic feedback system, such as system **400** depicted in FIG. **4**, including at least one sensor and at least one actuator positioned on a lower side of the input surface of virtual keyboard **108** (not depicted), proximate a contact location **110**. In many examples, actuators will be positioned proximate many, if not all, contact locations **110**. The haptic feedback system is configured to drive an actuator beneath a selected contact location, such as contact location **112** using a first waveform configured to provide a desired tactile sensation to a user by inducing mechanical vibrations in the plate under the selected contact location **112**.

**[0017]** To suppress propagation of such mechanical vibrations to other contact locations (i.e., vibratory crosstalk), in response to the driving of a feedback actuator in response to a user contact at contact location **112**, the haptic feedback system will also drive actuators beneath one or more other contact locations (such as contact location **114**) by a suppression waveform that is specifically configured to provide interference with the propagating vibrations, as those propagating vibrations exist at the other contact locations. For clarity of explanation in this disclosure, the suppression waveform configuration will primarily be discussed in the context of a waveform configured to provide destructive interference that will substantially reduce, and potentially cancel, propagating vibrations at these other contact locations. However, the suppression waveforms that may be used are not limited to just cancellation of the propagating vibrations. For example, the suppression waveform may be one that provides interference in terms of amplitude, frequency or both; which masks or otherwise changes the ultimate vibration at these other contact locations, thereby providing a user experience different than just reduction of the propagating vibrations. In the example where the suppression waveform is configured to at least partially cancel vibrations at the other contact locations, one example of a useful suppression waveform is one having an amplitude that is substantially equal to, and 180 degrees out of phase with, the propagating vibrations at the other contact location.

**[0018]** The specific operating parameters of the haptic feedback system will be dependent upon a number of factors, including the material and geometry of the surface through which feedback is being provided. As some general examples, actuators beneath contact locations **110** will be often be configured to produce vibrations having amplitudes within a range from approximately 10 microns to several hundred microns and having frequencies within a range from approximately 40 Hz to 250 Hz. In another example, the frequency range of the actuators ranges from 180 to 220 Hz. In an example where acoustic noise from such haptic feedback is undesirable, the frequency range can be limited to a range that is below 220 Hz, so that the vibrations are relatively inaudible. However, it should be understood that, depending on the implementation, other frequencies and amplitudes may be used. Many types and configurations of actuator may be used for inducing the vibratory inputs to the input surfaces. For example, electro-mechanic membrane actuators, such as those marketed as the P-25 Planar-mode Haptic Actuator, by Artificial Muscle, Inc. of Sunnyvale, Calif., or those marketed as the BST-5523SA magnetic buzzer by Bosan Hitech may be suitable for many applications, as will a number of other actuators known to those skilled in the art.

**[0019]** The amplitude of the propagating vibrations will vary as the vibrations propagate across an input surface from a selected input location, declining in amplitude in response to greater distance from the initial actuation site. Additionally, vibrations at neighboring locations induced by the identified suppression waveform applied to an actuator there may further introduce secondary vibrations that can also propa-